

# Arctic Oscillation and Polar Vortex Analysis and Forecasts

April 25, 2022

Dr. Judah Cohen from Atmospheric and Environmental Research (AER) embarked on an experimental process of regular research, review, and analysis of the Arctic Oscillation (AO) and Polar Vortex (PV). This analysis is intended to provide researchers and practitioners real-time insights on one of North America's and Europe's leading drivers for extreme and persistent temperature patterns.

During the winter schedule the blog is updated once every week. Snow accumulation forecasts replace precipitation forecasts. Also, there is renewed emphasis on ice and snow boundary conditions and their influence on hemispheric weather. With the start of spring we transition to a spring/summer schedule, which is once every two weeks. Snow accumulation forecasts will be replaced by precipitation forecasts. Also, there will be less emphasis on ice and snow boundary conditions and their influence on hemispheric weather.

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*The AO/PV blog is partially supported by NSF grant AGS: 1657748.*

## **Summary**

- The Arctic Oscillation (AO) is currently negative and is predicted to remain negative to neutral with mostly positive pressure/geopotential height anomalies across the Arctic including the North Atlantic side of the Arctic the next two weeks with mixed pressure/geopotential height anomalies across the mid-latitudes. The North Atlantic Oscillation (NAO) is also negative and is predicted to remain negative to neutral as pressure/geopotential height anomalies are predicted to remain mostly positive across Greenland the next two weeks.
- Ridging/positive geopotential height anomalies centered near Iceland but extending into Western Europe will force troughing/negative geopotential height anomalies across Northern and Eastern Europe. This pattern favors normal to above normal temperatures across Western Europe including the United Kingdom (UK) with normal to below normal temperatures across Northern and Eastern Europe the next two weeks.
- The general pattern across Asia the next two weeks is troughing/negative geopotential height anomalies across West Asia and centered over Novaya Zemlya (separating the Barents and Kara Seas) that extends into East Asia with ridging/positive geopotential height anomalies across Central Asia. This pattern

favors normal to below normal temperatures across Western and Eastern Asia with normal to above normal temperatures across Central and Southern Asia the next two weeks.

- The general pattern this week across North America is ridging/positive geopotential height anomalies centered near Alaska forcing downstream troughing/negative geopotential height anomalies across Canada and the Western and Eastern United States (US) with ridging across the Central US. However, the next week ridging/positive geopotential height anomalies will expand across Canada with troughing/negative geopotential height anomalies across Eastern Canada and the Eastern US. The pattern favors normal to below normal temperatures across much of Canada and the Western and Eastern US with normal to above normal temperatures across Alaska, and the Central US. Then next week normal to above normal temperatures will become widespread across Alaska, much of Canada and the Western US with normal to below normal temperatures across the Canadian Maritimes and the Eastern US.
- In the *Impacts* section the impacts of the polar vortex (PV) disruption are still recognizable in the two-week forecasts across the Northern Hemisphere (NH). However, I do expect that eventually the pattern will transition to a pattern more like the pattern of recent summers.
- *Impacts* section I continue to discuss my expectations of the impacts of the polar vortex (PV) disruption that is resulted in a Final Warming, though the impacts are more analogous to a classical sudden stratospheric warming (SSW) across the Northern Hemisphere (NH).

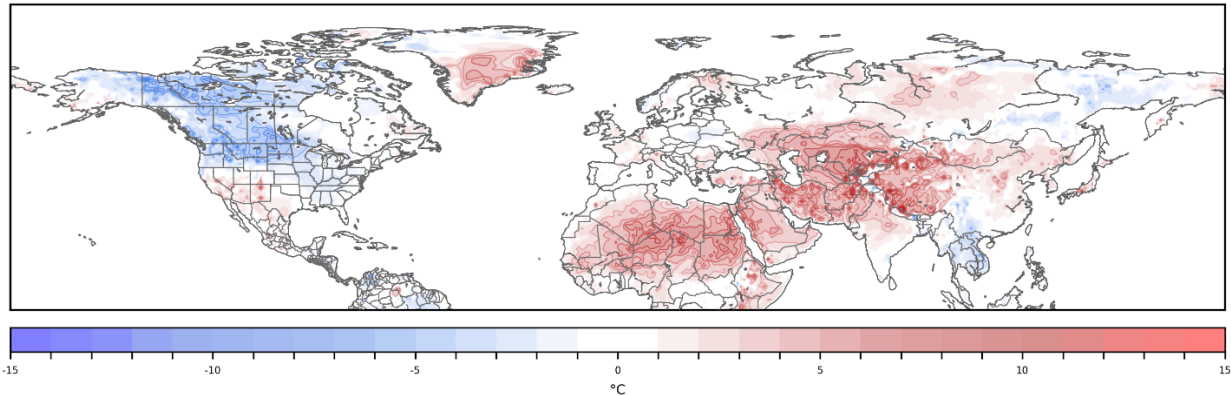
### ***Plain Language Summary***

The imprint of the large polar vortex disruption back in March is still visible in the current weather pattern and in the forecasts out to two weeks. This includes high latitude blocking including Greenland blocking/high pressure that favors colder and/or stormier weather across Europe and Northern Asia and eastern North America. However, over time I do expect the pattern to transition where the continents are dominated by high pressure/heat domes.

### ***Impacts***

The large PV disruption last month has resulted in relatively cold surface temperatures across large parts of Northern Eurasia but especially across North America so far in April (see **Figure i**). However, based on the latest polar cap geopotential height anomalies (PCHs) forecast in **Figure 11** it appears that the relationship between the large PV disruption from March and current and future weather across the Northern Hemisphere (NH) is waning. Though the PCH forecast could change in the coming days and needs to be monitored.

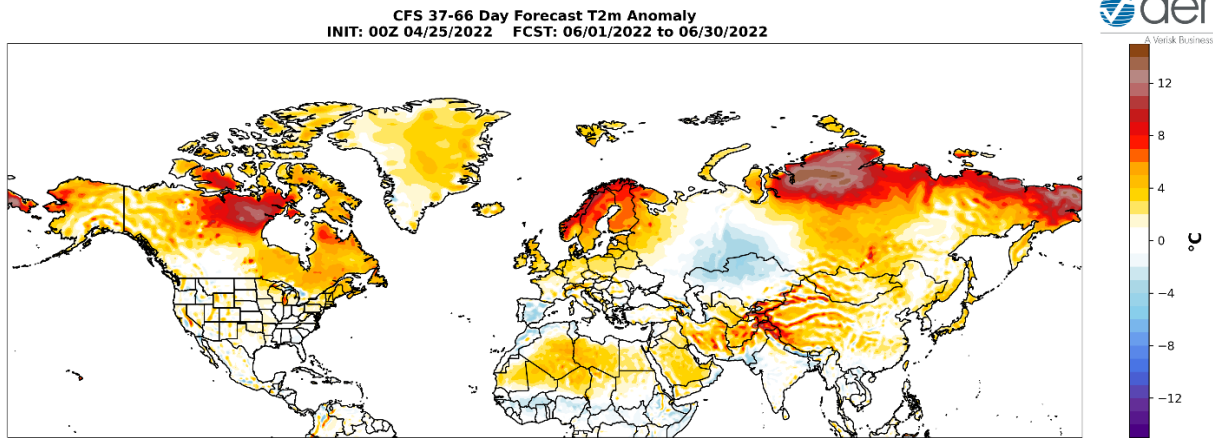
**GFS Monthly T2m Anomaly  
Apr 1-24, 2022**



**Figure i.** Observed surface temperature anomalies (°C; shading) from 1 April – 24 April 2022 based on the GFS analysis.

Often following large PV disruptions, high latitude blocking/high pressure is more frequent, in particular in and around Greenland, with troughing/lower pressure across Northern Eurasia and parts of North America. This is the current pattern across the NH and is predicted to mostly persist for the next two weeks as seen in **Figures 3, 5 and 8**. The pattern is predicted to weaken over the next two weeks, though beyond a week the forecast is of low confidence. This pattern is not the dominant summer pattern of recent years that are characterized by troughing/low pressure over the Central Arctic with high pressure/heat domes over the continents often centered across Eastern Europe, East Asia, western North America and the US East Coast with troughing/low pressure across Western Asia and even central North America.

As far as summer 2022, until proven otherwise, the trend is your friend and hence I see no reason not to favor a similar an atmospheric circulation this summer as well. Therefore, I would expect over the coming weeks in May and probably more likely in June that the circulation pattern will slowly transition from the current pattern of ridging/high pressure over the Arctic and troughing/low pressure over the continents to one of troughing/low pressure over the Arctic with ridging/high pressure over the mid-latitudes continents. The latest CFS forecast for June is consistent with my thinking and past recent summers (See **Figure ii**) thought temperatures could be warmer across western North America than depicted in the CFS forecast.

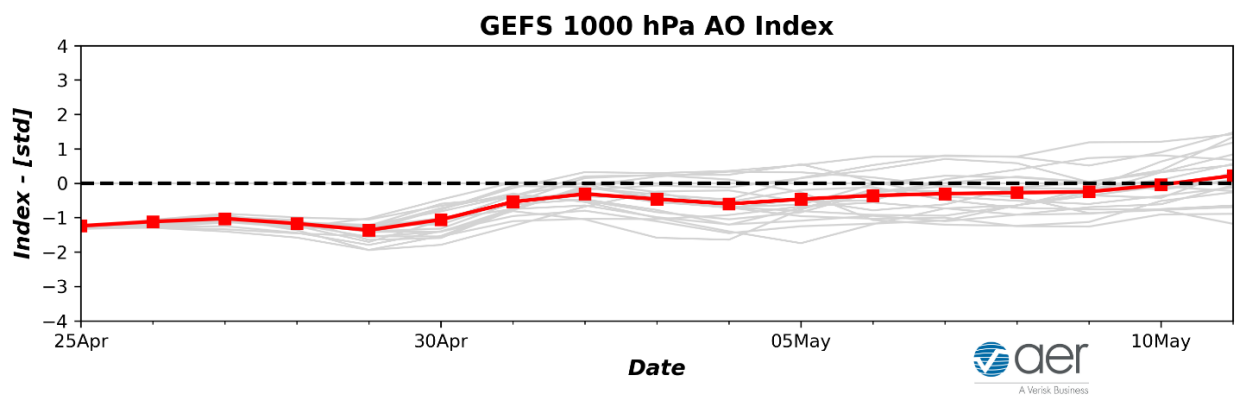


**Figure ii.** Forecasted average surface temperature anomalies ( $^{\circ}\text{C}$ ; shading) across the Northern Hemisphere for June 2022. The forecasts are from the 00Z 25 April 2022 CFS.

The spring will likely be characterized by widespread relatively cold temperatures across the continents, especially North America. In addition, snow cover is still relatively widespread across the NH, especially North America and therefore cool temperatures could persist for a while. Still, I expect that the character or pattern of summer surface temperature anomalies will be quite different despite the current extent of cool temperatures and snow cover.

### 1-5 day

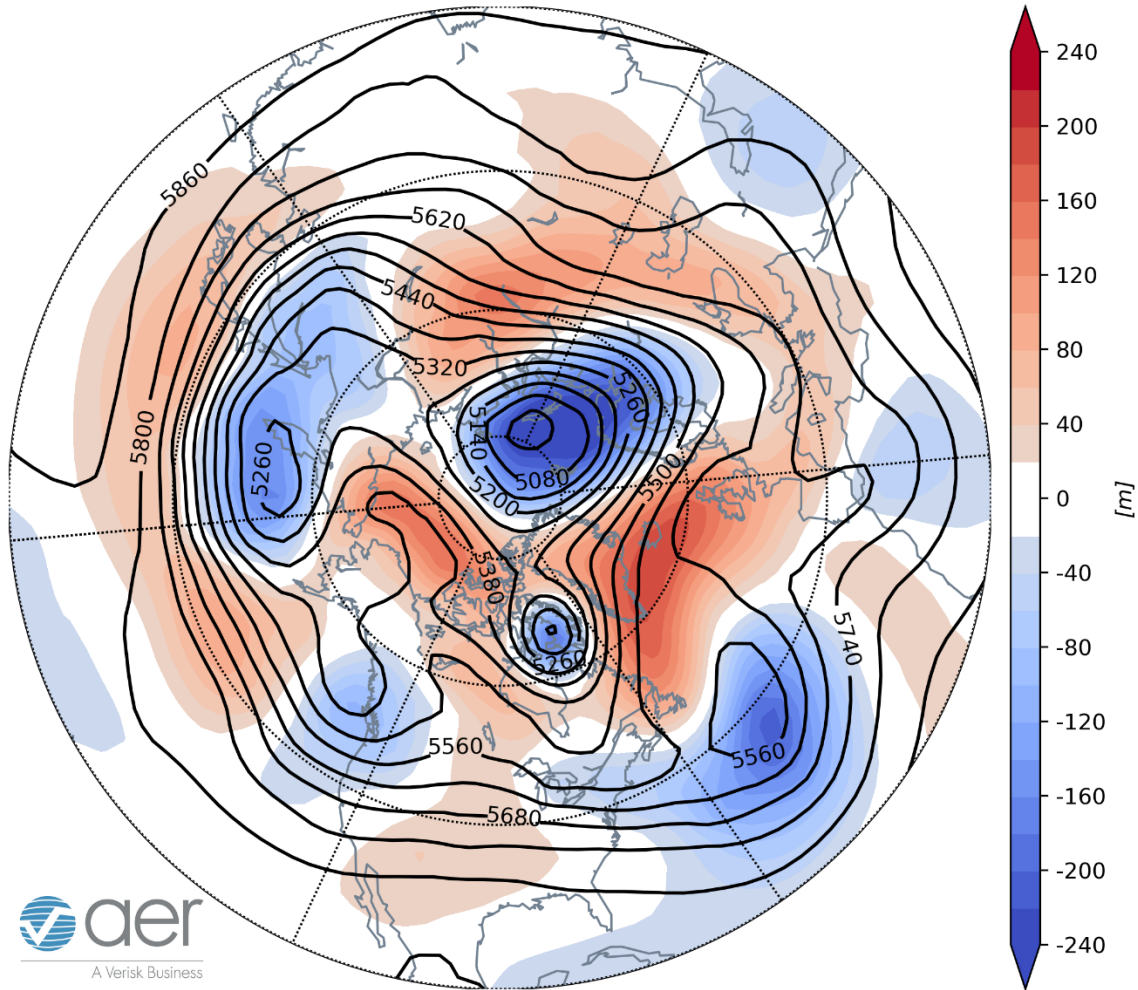
The AO is predicted to be negative this week (**Figure 1**) as geopotential height anomalies are predicted to be mostly positive across the Arctic with mixed geopotential height anomalies across the mid-latitudes of the NH (**Figure 2**). And with positive geopotential height anomalies predicted across Greenland (**Figure 2**), the NAO is predicted to be negative this week as well (**Figure 1**).



**Figure 1.** The predicted daily-mean AO at 1000 hPa from the 00Z 25 April 2022 GFS ensemble. Gray lines indicate the AO index from each individual ensemble member, with the ensemble-mean AO index given by the red line with squares.

Ridging/positive geopotential height anomalies in the central North Atlantic centered near Iceland but extending into Western and Southern Europe will support troughing/negative geopotential height anomalies across Northern and Eastern Europe (**Figures 2**). This will result in normal to above normal temperatures across Western and Southern Europe including the UK with normal to below normal temperatures across Northern and Eastern Europe (**Figure 3**). Deep troughing/negative geopotential height anomalies centered over Novaya Zemlya (separating the Barents and Kara Seas) will extend both southward across Western Asia and eastward across Eastern Asia separated by ridging/positive geopotential height anomalies across Central Asia this period (**Figure 2**). This pattern favors normal to below normal temperatures across Northwestern and Eastern Asia with normal to above normal temperatures across Central and Southern Asia (**Figure 3**).

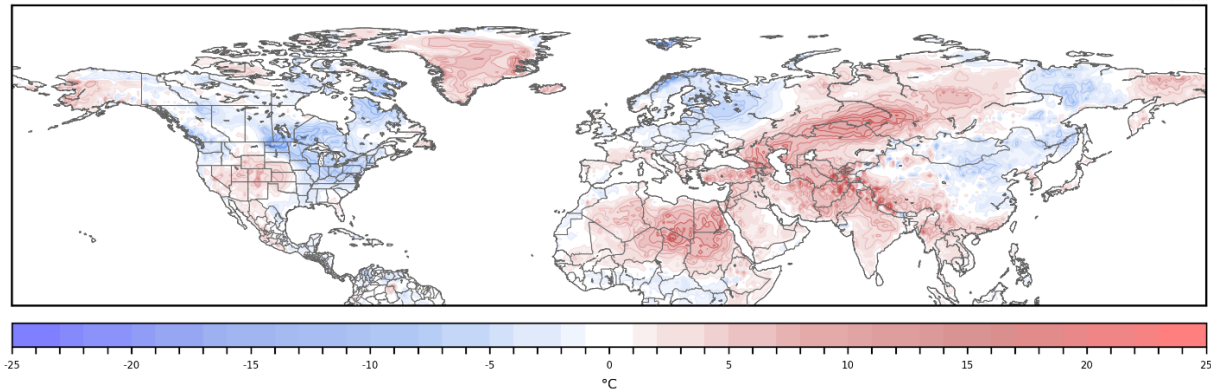
**GEFS 1-5 Day Forecast 500 mb GPH/GPH Anomaly**  
**INIT: 00Z 04/25/2022 FCST: 04/26/2022 to 04/30/2022**



**Figure 2.** Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 26 – 30 April 2022. The forecasts are from the 00z 25 April 2022 GFS ensemble.

Across North America the general pattern is ridging/positive geopotential height anomalies centered near Alaska supporting troughing/negative geopotential height anomalies across much of Canada and the Western and Eastern US separated by ridging/positive geopotential height anomalies across the Central US (**Figure 2**). The pattern will favor normal to above normal temperatures across Alaska and the Central US with normal to below normal temperatures across much of Canada and the Western and Eastern US (**Figure 3**).

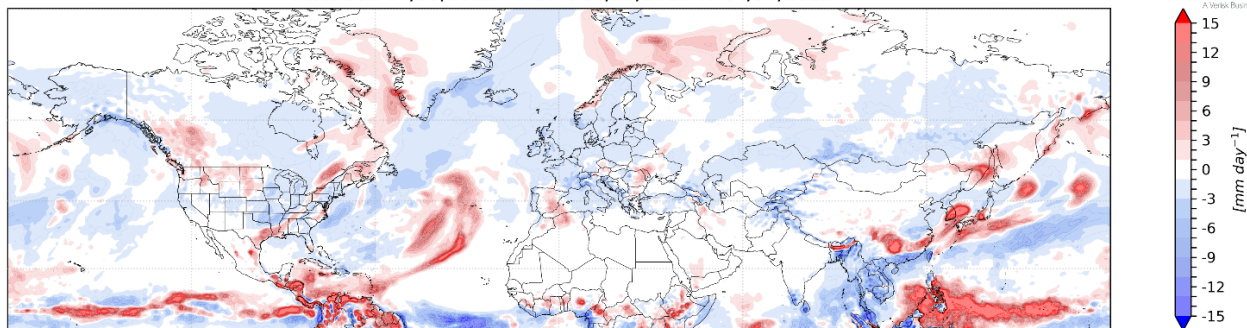
**GFS 1-5 Day Forecast T2m Anomaly**  
**INIT: 00Z 04/25/2022 FCST: 04/26/2022 to 04/30/2022**



**Figure 3.** Forecasted surface temperature anomalies (°C; shading) from 26 – 30 April 2022. The forecast is from the 00Z 25 April 2022 GFS ensemble.

Mostly below normal precipitation is predicted across Eurasia with above normal precipitation predicted for East Asia and parts of Siberia (**Figure 4**). Mostly below normal precipitation is predicted across North America with above normal precipitation predicted for Western Canada, the Canadian Maritimes and parts of the Eastern US (**Figure 4**).

**GEFS 1-5 Day Forecast PRATE Anomaly**  
**INIT: 00Z 04/25/2022 FCST: 04/26/2022 to 04/30/2022**



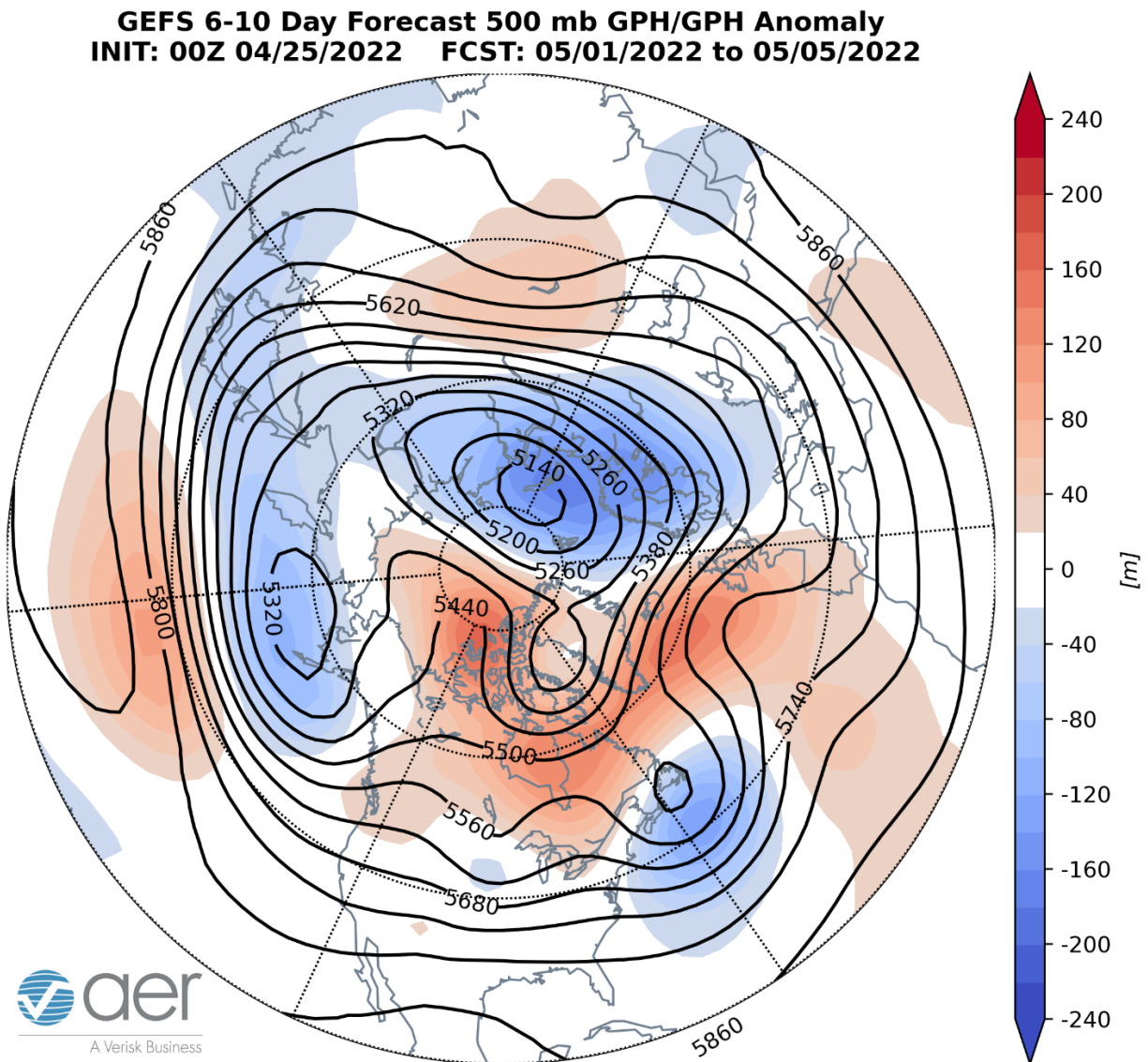
**Figure 4.** Forecasted precipitation rate (mm/day; shading) from 26 – 30 April 2022. The forecast is from the 00Z 25 April 2022 GEPS ensemble.

*Mid-Term*

*6-10 day*

The AO is predicted to remain in negative territory this period (**Figure 1**) as geopotential height anomalies remain mostly positive across the Arctic with mixed geopotential height anomalies across the mid-latitudes of the NH (**Figure 5**). And as geopotential

height anomalies remain positive across Greenland (Figure 5), the NAO is predicted to also remain negative this period.

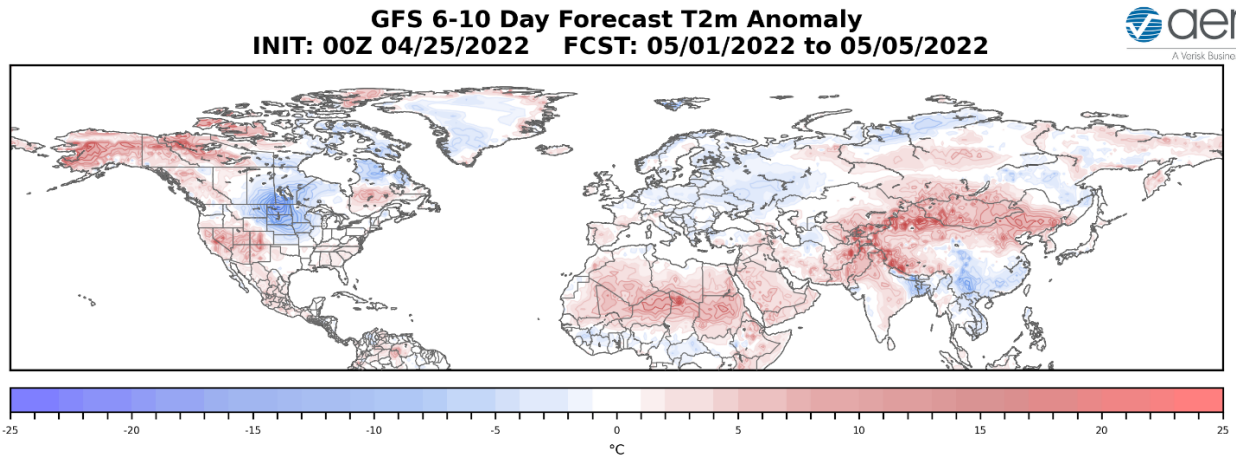


**Figure 5.** Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 1 – 5 May 2022. The forecasts are from the 00z 25 April 2022 GFS ensemble.

Ridging/positive geopotential height anomalies persistent near Iceland and extending into Western Europe will continue to support troughing/negative geopotential height anomalies across Northern and Eastern Europe this period (Figures 5). This will result in normal to above normal temperatures across Western Europe including the UK with normal to below normal temperatures across Northern and Eastern Europe (Figure 6). The pattern across Asia is predicted to persist with troughing/negative geopotential

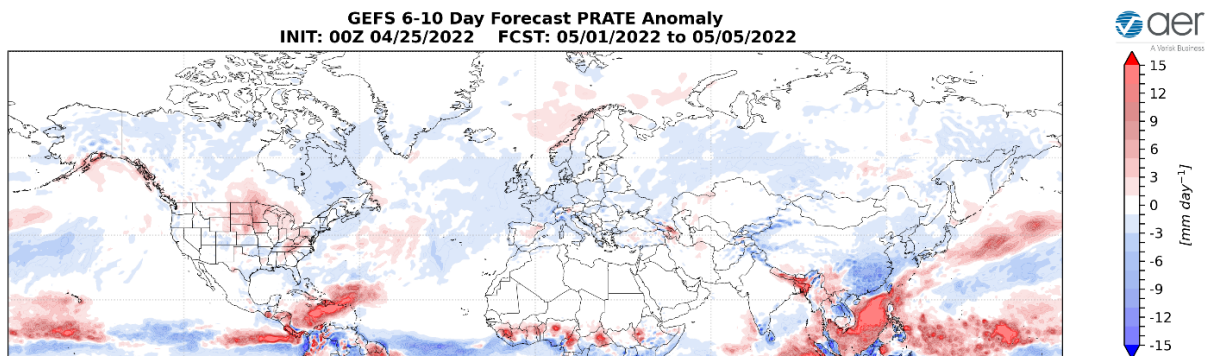


height anomalies across Western and Eastern Asia with ridging/positive geopotential height anomalies across Central Asia this period (**Figure 5**). This pattern favors widespread normal to below normal temperatures across much of Western and Eastern Asia with normal to above normal temperatures across Central Asia (**Figure 6**).



**Figure 6.** Forecasted surface temperature anomalies (°C; shading) from 1 – 5 May 2022. The forecasts are from the 00Z 25 April 2022 GFS ensemble.

Persistent ridging/positive geopotential height anomalies north of Alaska will spread into Western and Northern Canada and the Western and Eastern US with troughing/negative geopotential height anomalies across Central Canada, the Canadian Maritimes and the Central US (**Figure 5**). This will favor normal to above normal temperatures across Alaska, Northern and Western Canada and the Western and Eastern US with normal to below normal temperatures across Central Canada and the Central US (**Figure 6**).



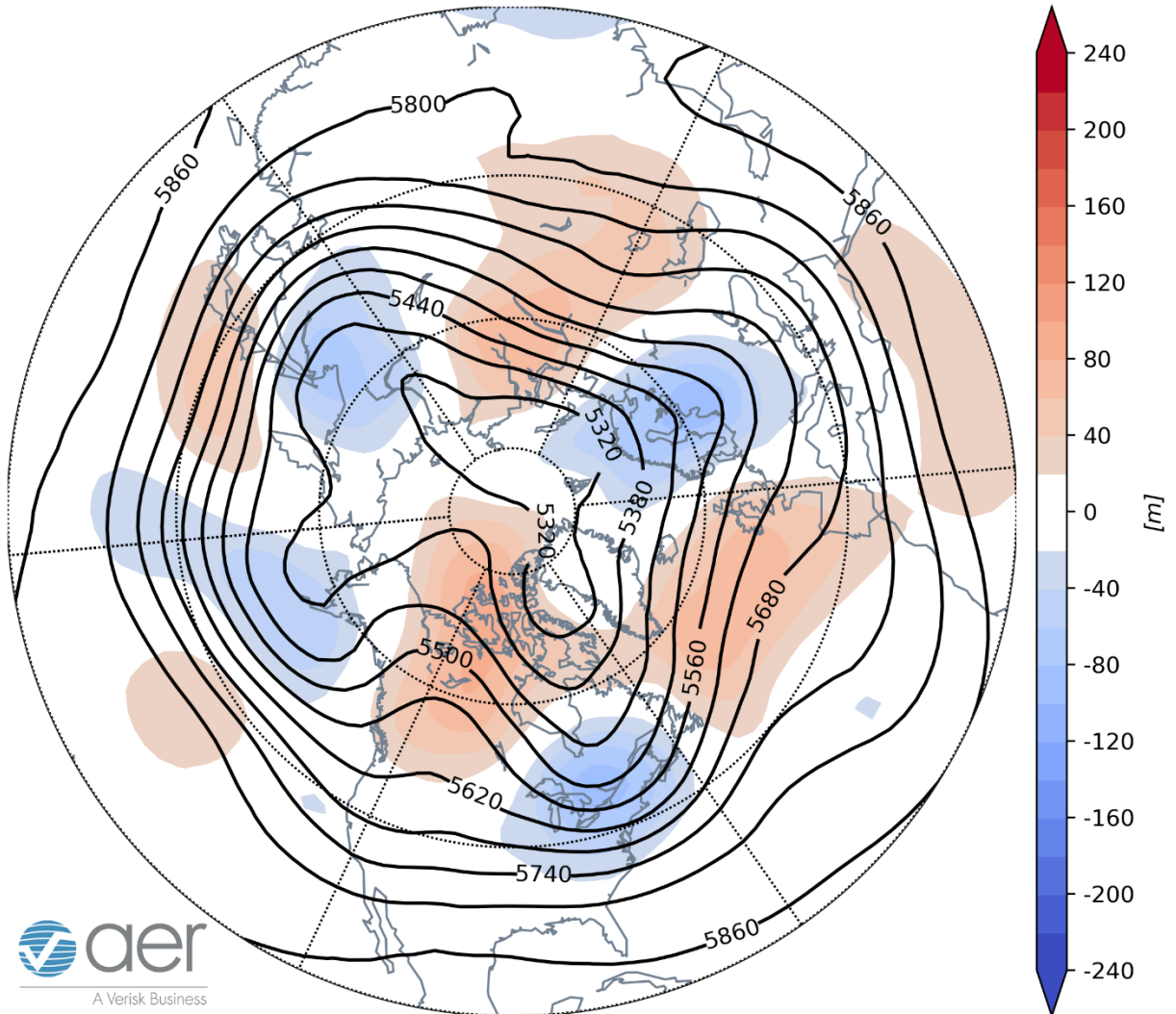
**Figure 7.** Forecasted precipitation rate (mm/day; shading) from 1 – 5 May 2022. The forecast is from the 00Z 25 April 2022 GEFS ensemble.

Mostly below normal precipitation is predicted across Eurasia with above normal precipitation predicted for Southern and Eastern Asia and northern Scandinavian (**Figure 7**). Mostly below normal precipitation is predicted across North America with above normal precipitation predicted for Southern Alaska, the West Coast of Canada, the Canadian Maritimes, the Great Lakes and the Eastern US (**Figure 7**).

11-15 day

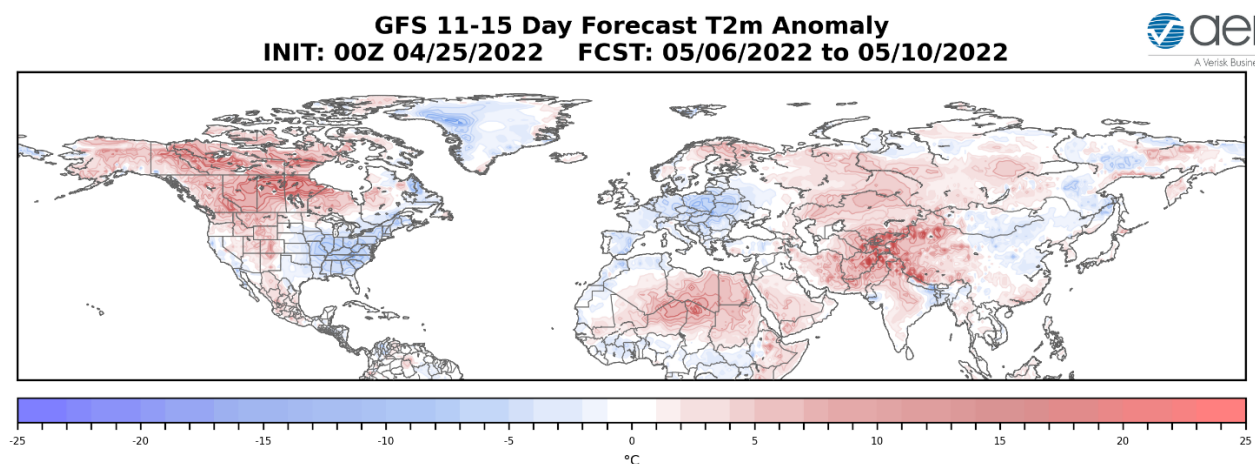
Geopotential height anomalies are predicted to remain mostly positive in the Central Arctic this period (**Figure 8**), therefore the AO should remain on the negative side of neutral (**Figure 1**). With predicted weak and positive pressure/geopotential height anomalies across Greenland (**Figure 8**), the NAO is predicted to also remain on the negative side of neutral this period.

**GEFS 11-15 Day Forecast 500 mb GPH/GPH Anomaly**  
**INIT: 00Z 04/25/2022 FCST: 05/06/2022 to 05/10/2022**



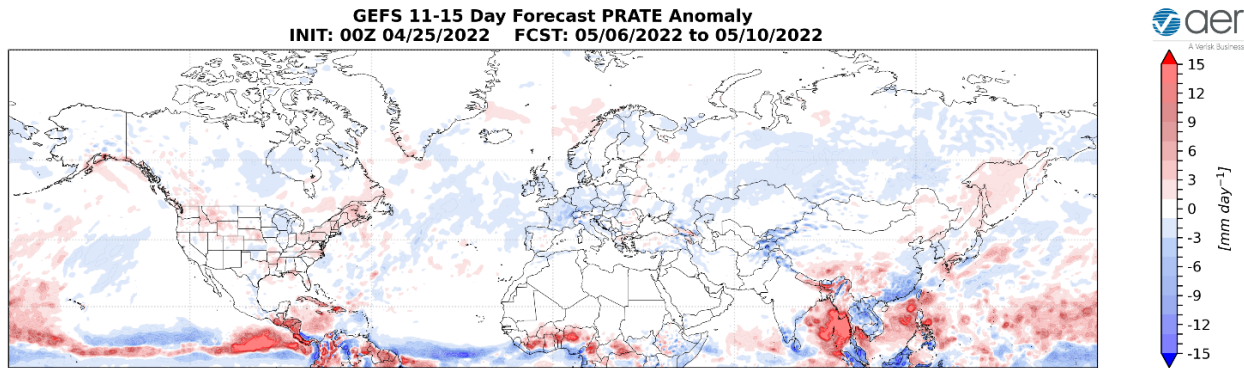
**Figure 8.** Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 6 – 10 May 2022. The forecasts are from the 00z 25 April 2022 GFS ensemble.

Persistent ridging/positive geopotential height anomalies centered south of Iceland will continue to support troughing/negative geopotential height anomalies across Eastern Europe resulting in mostly northerly flow across much of Europe this period (**Figure 8**). This pattern favors normal to below normal temperatures widespread across Western, Central and Eastern Europe including the UK with normal to above normal temperatures mostly limited to Scandinavia (**Figures 9**). The pattern of troughing/negative geopotential height anomalies across Western and Eastern Asia separated by ridging/positive geopotential height anomalies across Central Asia is predicted to persist this period (**Figure 8**). This pattern favors widespread normal to above normal temperatures across the interior of Asia with normal to below normal temperatures mostly limited to far Western and Eastern Asia (**Figure 9**).



**Figure 9.** Forecasted surface temperature anomalies (°C; shading) from 6 – 10 May 2022. The forecasts are from the 00z 25 April 2022 GFS ensemble.

Ridging/positive geopotential height anomalies centered near Alaska are predicted to continue to spread into Western Canada and the Western US forcing downstream troughing/negative geopotential height anomalies across Eastern Canada and the Eastern US this period (**Figure 8**). This pattern favors widespread normal to above normal temperatures across Alaska, much of Canada and the Western US with normal to below normal temperatures limited to the Canadian Maritimes and the Eastern US (**Figure 9**).



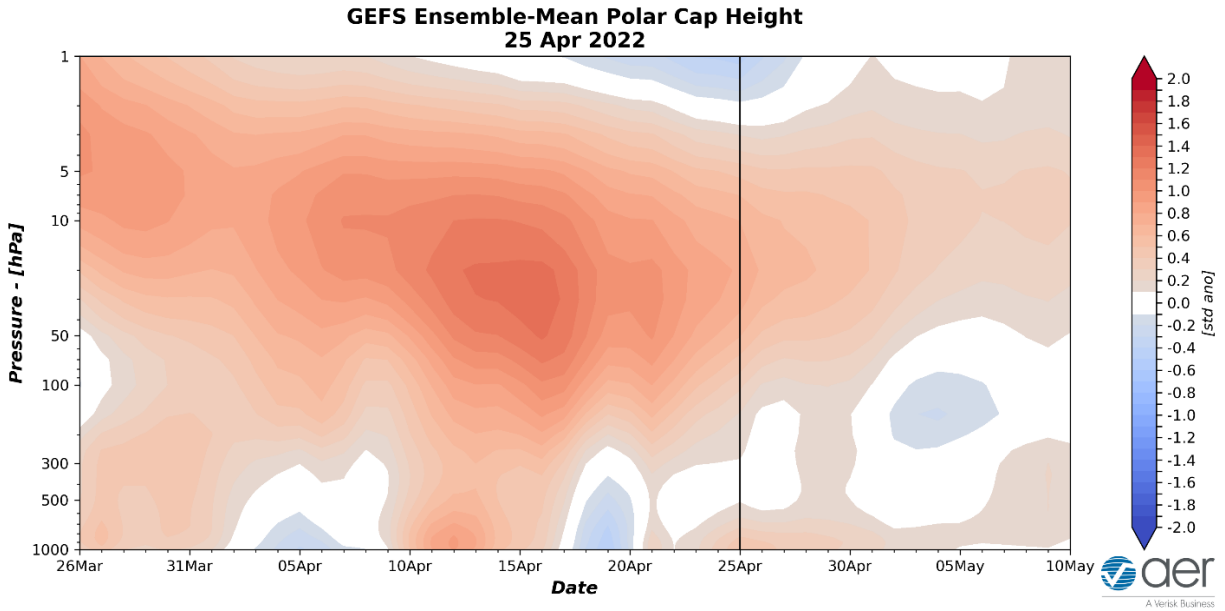
**Figure 10.** Forecasted precipitation rate (mm/day; shading) from 6 – 10 May 2022. The forecast is from the 00Z 25 April 2022 GEPS ensemble.

Mostly below normal precipitation is predicted across Eurasia with above normal precipitation predicted for East Asia and parts of Siberia (**Figure 10**). Mostly below normal precipitation is predicted across North America with above normal precipitation predicted for Western Canada, the Canadian Maritimes and the Eastern US (**Figure 10**).

### *Longer Term*

#### *30-day*

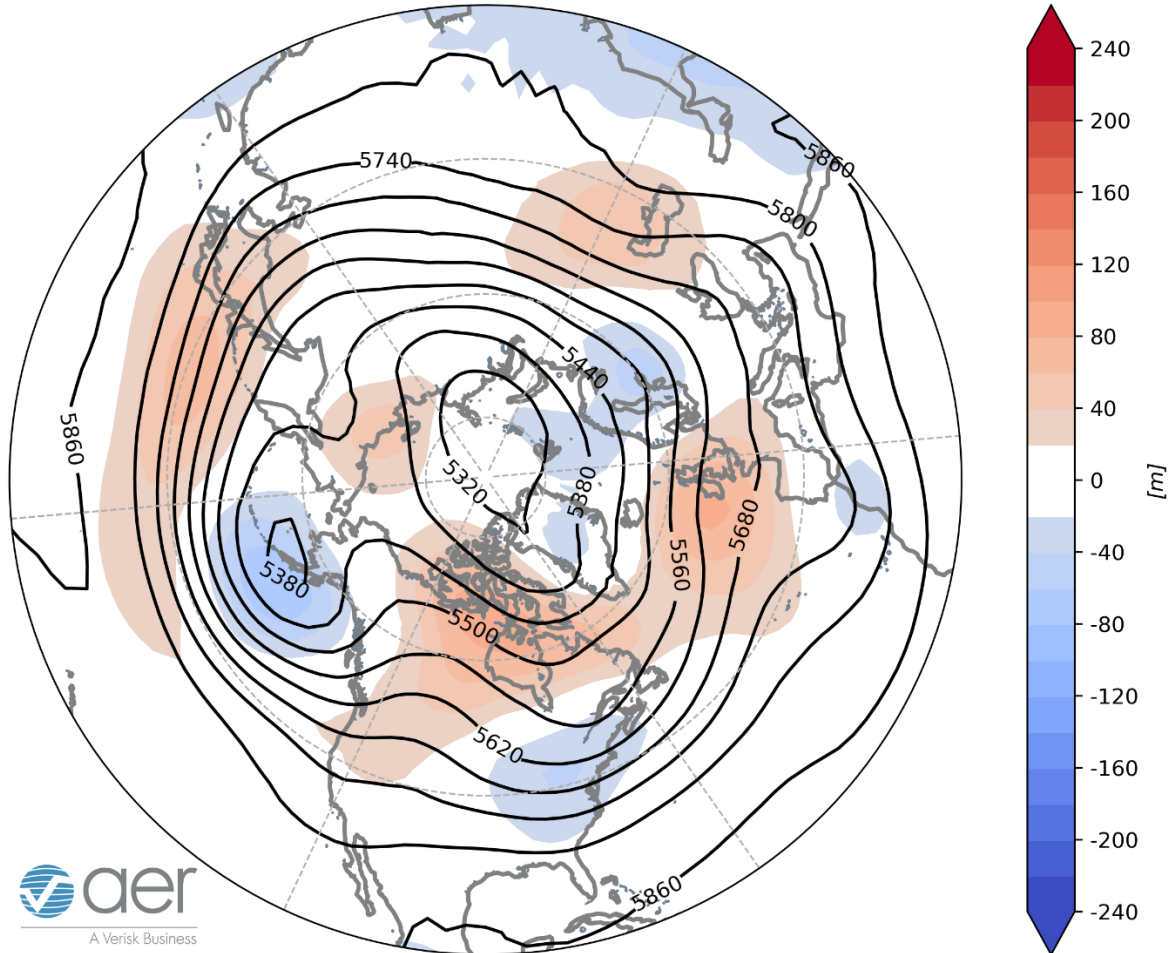
The latest plot of the polar cap geopotential height anomalies (PCHs) currently shows warm/positive PCHs throughout in much of the stratosphere and troposphere with cold/negative PCHs limited to the upper stratosphere. Warm/positive PCHs are predicted to persist in the middle stratosphere and the lower troposphere for the next two weeks while cold/negative PCHs form in the lower stratosphere and upper troposphere next week (**Figure 11**). Overall, the warm positive PCHs are predicted to wane over the next two weeks (**Figure 11**).



**Figure 11.** Observed and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecast is from the 00Z 25 April 2022 GFS ensemble.

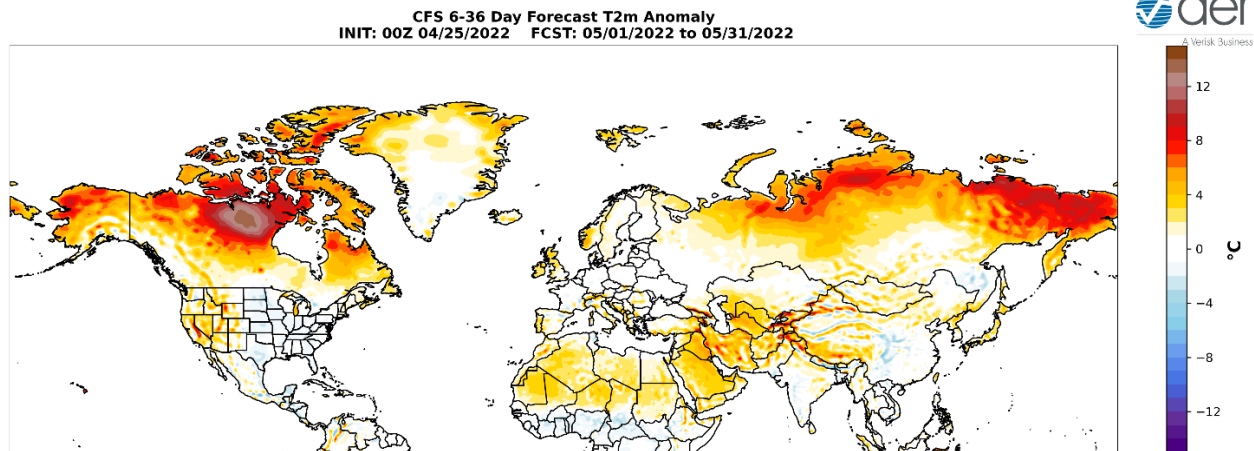
The normal to above normal PCHs predicted the next two weeks in the lower troposphere are consistent with the predicted negative surface AO the next two weeks (**Figure 1**).

**CFS 500 hPa Forecast Anomaly May 2022**  
**Valid as of 25 Apr 2022**



**Figure 12.** Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for May 2022. The forecasts are from the 00Z 25 April 2022 CFS.

I include in this week's blog the monthly 500 hPa geopotential heights (**Figure 12**) and surface temperatures for May (**Figure 15**) from the Climate Forecast System (CFS; the plots represent yesterday's four ensemble members). The forecast for the troposphere is ridging centered just west of the UK, Western Asia, Eastern Siberia and Central Canada with troughing across Southern Europe, Central and East Asia, the Aleutians, the Gulf of Alaska into the west coast of Canada and the Northeastern US (**Figure 12**). This pattern favors seasonable to relatively warm temperatures across the Northern Europe, Northern and Western Asia, Alaska, Northern Canada and the Western US with seasonable to relatively cool temperatures across Southern Europe, East Asia, and the Eastern US (**Figure 13**).

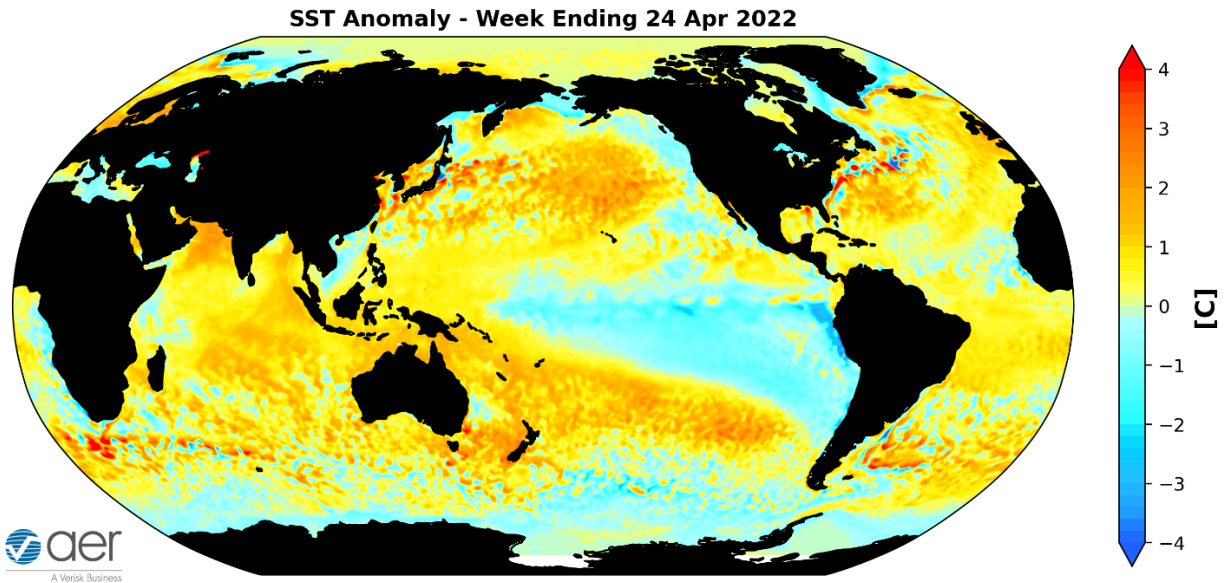


**Figure 15.** Forecasted average surface temperature anomalies (°C; shading) across the Northern Hemisphere for May 2022. The forecasts are from the 00Z 25 April 2022 CFS.

### *Surface Boundary Conditions*

#### *SSTs/El Niño/Southern Oscillation*

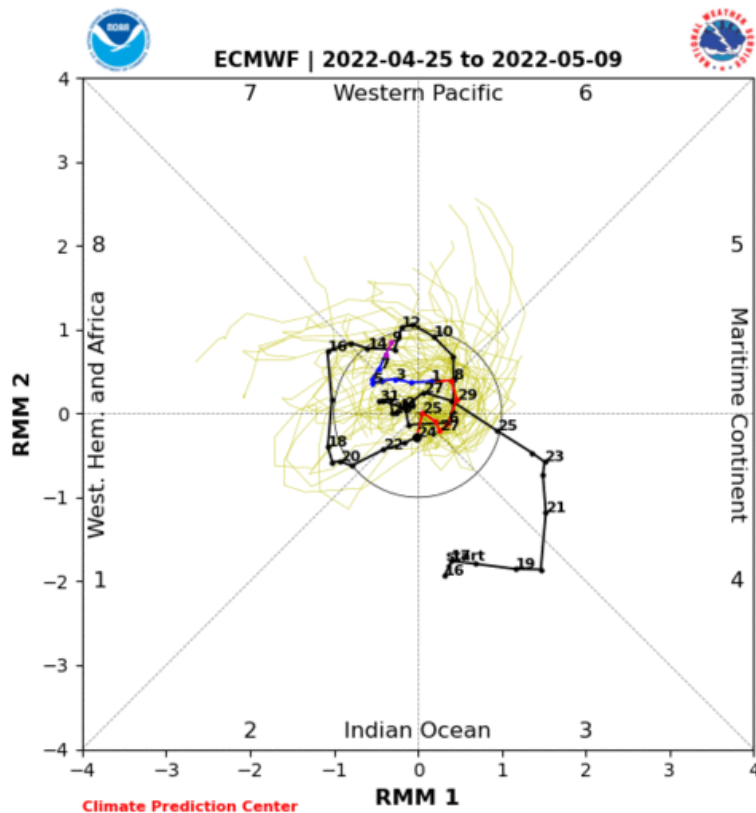
Equatorial Pacific sea surface temperatures (SSTs) anomalies are below normal and we continue to observe weak La Niña conditions (**Figure 16**) and La Niña conditions are expected through the spring. Observed SSTs across the NH remain well above normal especially in the central North Pacific (west of recent years), the western North Pacific and offshore of eastern North America though below normal SSTs exist regionally especially in the North Pacific. Not my expertise but the SST pattern in the North Pacific are strongly resembling a negative Pacific Decadal Oscillation (PDO) pattern that favors colder temperatures across northwestern North America and milder temperatures across southeastern North America.



**Figure 16.** The latest weekly-mean global SST anomalies (ending 24 April 2022). Data from NOAA OI High-Resolution dataset.

Currently no phase of the Madden Julian Oscillation (MJO) is favored (**Figure 17**). The forecasts are for the MJO to remain weak where no phase is favored. Therefore it is hard to for me to see that the MJO is likely influencing the weather across North America. But admittedly this is outside of my expertise.





**Figure 17.** Past and forecast values of the MJO index. Forecast values from the 00Z 25 April 2022 ECMWF model. Yellow lines indicate individual ensemble-member forecasts, with the green line showing the ensemble-mean. A measure of the model “spread” is denoted by the gray shading. Sector numbers indicate the phase of the MJO, with geographical labels indicating where anomalous convection occurs during that phase. Image source: <http://www.atmos.albany.edu/facstaff/roundy/waves/phasediags.html>

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We appreciate your taking the time to read the public Arctic Oscillation blog from Dr. Judah Cohen and the AER Seasonal Forecasting team.

Dr. Cohen’s detailed monthly seasonal forecast, **sCast**, is also available for purchase. **sCast** provides a monthly 30-60-90-180-day outlook into temperature and

precipitation, solar flux and wind anomalies across the globe, and regional population weighted cooling and heating degree forecasts for the US.

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